instruction manual

MODEL "MA" NOBATRONS

SORENSEN
A Unit of Raytheon
Richards Avenue, South Norwalk, Connecticut

MA-28-30

OFFICIAL RECORDS STATION
FILE COPY
FACILITIES

GENERAL INFORMATION

PLEASE READ THIS MANUAL. We think it will help you to obtain the maximum performance from your new Sorensen instrument.

SHIPPING DAMAGE

Sometimes instruments are damaged in transit. We strongly suggest that you inspect and test your instrument as soon as you receive it. If the instrument is damaged or if it fails to operate properly, you should ask the carrier to inspect the shipment. The carrier's claim agent will prepare a report of damage which you should send to us. We will then tell you how to have the instrument repaired or replaced.

SERVICE INFORMATION

If you have any questions about the operation, repair, or servicing of a Sorensen instrument, please contact our local representatives. (A list of representatives is included with this manual.) If it is more convenient you may contact us directly at the Service Department, Sorensen, Richards Avenue, South Norwalk, Connecticut.

IMPORTANT

BE SURE TO INCLUDE THE MODEL & SERIAL NUMBER IN ALL CORRESPONDENCE CONCERNING THIS INSTRUMENT. WITHOUT THIS INFORMATION WE MAY NOT BE ABLE TO GIVE YOU PROMPT AND ACCURATE SERVICE.

RETURNS TO THE FACTORY

Should you decide to return an instrument to us for repair, please contact us for authorization to make shipment. We have a number of local service facilities in the United States and Canada which are equipped and staffed to provide you with fast, efficient service. For this reason, we reserve the right to refuse unauthorized shipments to our plant.

WARRANTY

This instrument is warranted by Sorensen/Unit of Raytheon, to be free from defects in material and workmanship. Our obligation under the warranty is limited to servicing the instrument and replacing defective parts* when the instrument is returned to the factory with transportation charges prepaid. No other warranties may be implied. The period of warranty is one year after the delivery of the instrument to the original purchaser. Defects caused by improper operating conditions, accidents, misuse, negligence, and the alteration or removal of the nameplate, will void the warranty.

*With the exception of tubes and fuses.

MODEL

"MA"

NOBATRONS

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SORENSEN/A UNIT OF RAYTHEON, Richards Ave., So. Norwalk, Connecticut

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II. SPECIFICATIONS

"MA" Nobatrons are tubeless, DC power supplies designed to provide a continuously adjustable, regulated, output over a fixed voltage range.

MODEL		MA6-60	MA12-30	MA12-60	MA28-30
INPUT POWER	Voltage	105 to 125 VAC, Single Phase 60 cycles			
	Current	15A	15A	25A	25A
OUTPUT POWER	Voltage	6.3	12.6	12.6	28
	Range	4.5-9	9-18	9-18	18-36
	Current	60A	30A	60A	30A
REGULATION					
	Line	±0.1%			
	Load	±0.2%			
RIPPLE		1% RMS at Nominal Output Voltage			
Response Time		0.15 Seconds Typical			
Max. Excursion		20% of Nominal Output Voltage Typical			
AMBIENT TEMPERATURE 15°C (59°F) to 40°C (104°F)					
WEIGHT (NET)		107 lbs	102 lbs	127 lbs	122 lbs
Dimensions (ins.)					
	Width	19	19	19-1/2	19-1/2
	Depth	16	16	16	16
	Height	12-3/4	12-3/4	16-1/4	16-1/4
Rack Height		12-1/4	12-1/4	15-3/4	15-3/4
PROTECTIVE DEVICES		15A Fuse	15A Fuse	30A Fuse	25A Fuse
		Overcurrent Circuit Breaker & On-Off Switch			
OUTPUT TERMINALS	Front		Binding Posts		Binding Posts
	Rear	TERMINAL BOARDS			
METERS		Optional		Standard	

INPUT FREQUENCY

"MA" Nobatrons are designed for a nominal input frequency of 60 cps. Typical units will operate within specifications over the range of 57-63 cps. A wider frequency range may be used, however, a degeneration in performance will result (poor regulation, higher ripple, etc.)

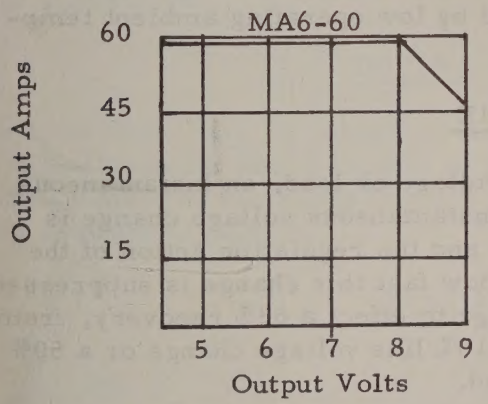
INPUT VOLTAGE

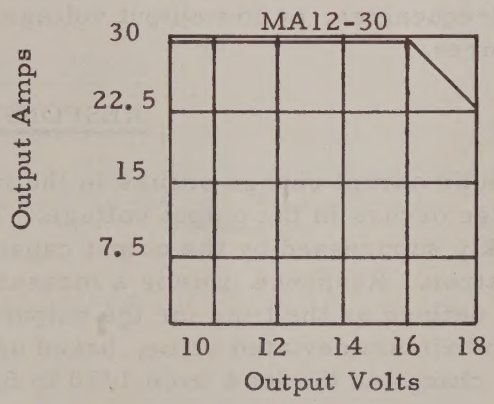
Operation at an input voltage below 105 is possible, although poorer regulation will result, but the output current may have to be derated. Input voltages above 130VAC may result in damage to components.

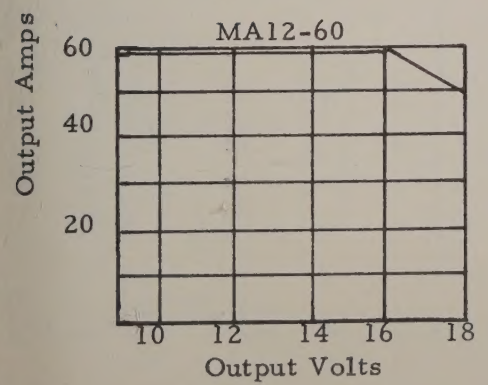
OUTPUT VOLTAGES & CURRENTS

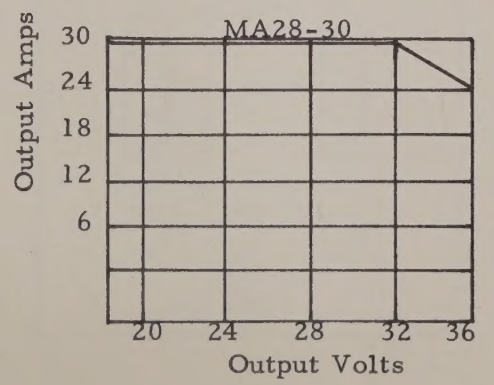
Typical Nobatrons will adjust over the entire range at all loads. Some Nobatrons, however, may not adjust to minimum voltage at no load-high line or minimum voltage at full load-low line.

The charts below show derating curves at the full load high output region. These curves are based on the temperature rise of the wound components, and operation in the region above the curve will reduce life of transformers.









REGULATION ACCURACY

The regulation accuracy, for line changes, is defined as ±0.1% for any line variations between 105-125VAC. This means that, as the input voltage is varied from 105-125VAC, the change in the output voltage will be less than 0.2% total. This change in output voltage is not necessarily uniform.

The regulation accuracy, for load changes, is defined as ±0.2% (±0.25% Model MA6-60) for any load change from no load current to full load current with a fixed input voltage. This means that, with a constant input voltage, the load may be switched from no load current to full rated load, and the output voltage will change less than 0.4% total. Typical data for a one-half load change is ±0.1% output voltage change.

The stated load regulation accuracy applies at the nominal output voltage, however, typically the accuracy will hold over a ±10% output voltage adjustment. Over the full adjustment range, the regulation accuracy will decrease. Typical regulation at the extreme ends of the output range is ±0.5%.

RIPPLE

The ripple specification is defined as 1% RMS at the nominal output voltage setting, and may increase at other voltage settings. The above conditions apply only to 60 cycle operation. The ripple will be increased by other input frequencies, by low output voltages, and by low operating ambient temperatures.

RESPONSE TIME

When an abrupt change occurs in the input voltage or load, an instantaneous change occurs in the output voltage. This instantaneous voltage change is quickly suppressed by the output capacitors and the regulation action of the Nobatron. Response time is a measure of how fast this change is suppressed. It is defined as the time for the output voltage to effect a 63% recovery, from the maximum deviated value, based upon a 10% line voltage change or a 50% step change in the load from 1/10 to full load.

III. INSTALLATION AND OPERATION

RACK MOUNTING OR BENCH OPERATION

These Nobatrons when originally purchased may be supplied self-contained for bench top operation, or equipped for mounting in a standard 19" relay rack. In the event it is later desired to rack mount a self-contained unit or vice versa, this may be accomplished without difficulty. The user should contact our local representative or the Sorensen Service Department for the necessary parts and instructions for conversion.

INPUT CONNECTIONS

Models MA6-60, MA12-30 The input power is applied by means of a line cord that is equipped with a three prong plug. Since the third prong of this plug is attached to the chassis of the Nobatron, connection of the line cord to a suitable three wire receptacle automatically grounds the Nobatron. If a three wire receptacle is not available, then an adapter should be used. In this case, the third wire from the adapter should be connected to ground.

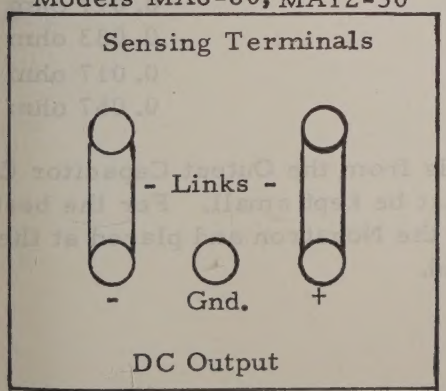
Models MA12-60, MA28-30 The input power is connected directly to the terminal board located on the rear chassis of the Nobatron. Upon removing the rear cover, this terminal board will be exposed. A separate ground terminal is provided.

OUTPUT CONNECTIONS

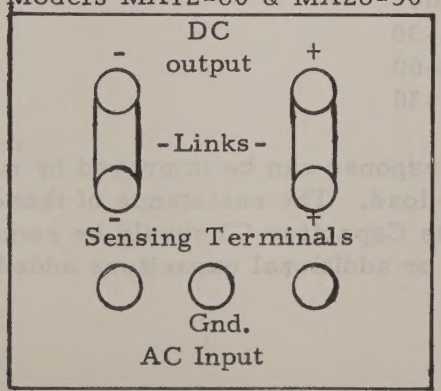
The load wires may be connected either to the binding posts on the front panel or to the terminal board located at the rear. (The 60A Nobatrons do not have Binding Posts on the Front Panel.) When making the output connections, be sure to observe polarity.

Terminal Board Layout

Models MA6-60, MA12-30



Models MA12-60 & MA28-30

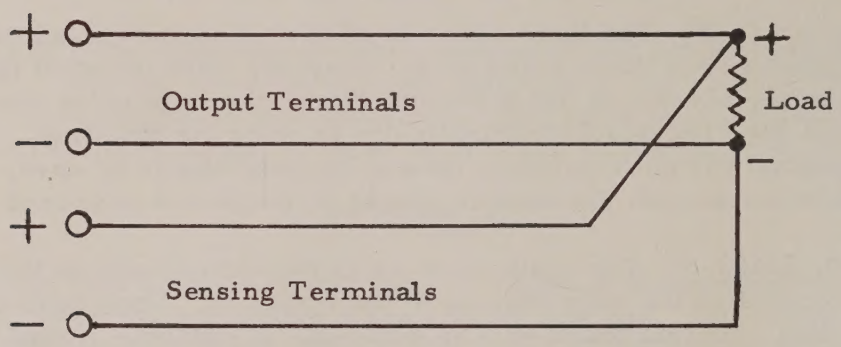


REMOTE SENSING

Remote sensing should be used to eliminate the voltage drop occurring in the load connecting wires. This voltage drop, if present, will adversely affect the load regulation.

The connections for remote sensing are located on the terminal board at the rear of the Nobatron. For normal operation (no remote sensing) the output terminals are connected to the sensing terminals by two links. When remote sensing, these links must be disconnected from the sensing terminals.

Typical Remote Sensing Arrangement



When remote sensing the resistance of both the power and sensing leads should be kept as low as possible. Voltage drops in the power leads shift the output voltage range, at maximum output heavy load, by the amount of drop in the leads. This voltage drop will cause some deterioration of load regulation. The chart below lists the recommended maximum voltage drop that can be tolerated by each model, and the corresponding resistance. Resistance in the sensing leads deteriorates regulation approximately 0.1% for every 0.1 ohm.

Model	Max. Volt Drop	Resistance
MA6-60	1.0	0.017 ohm
MA12-30	1.0	0.033 ohm
MA12-60	1.0	0.017 ohm
MA28-30	2.0	0.067 ohm

The response can be improved by running leads from the Output Capacitor C3 to the load. The resistance of these leads must be kept small. For the best results Capacitor C3 should be removed from the Nobatron and placed at the load, or additional capacitors added at the load.

GROUNDING OF OUTPUT

The DC output of these instruments is floating, hence either terminal may be grounded.

CAUTION: In all cases be sure that the Nobatron's output be grounded to an external potential of not over 250V to ground. Exceeding this potential may result in a breakdown of the instrument's components.

AIR CIRCULATION

Natural convection cooling is employed. The installation must be such that free air circulation is available through the bottom, back and top of the cabinet. On self-contained units the feet elevate the instrument 1" to provide air access. In rack installations a similar provision should be made.

PROTECTIVE DEVICES

Overcurrent Breaker: The overcurrent breaker is combined with the On-Off Switch. This breaker-switch is a single pole type, thus even when it is in the off position voltages exist at various points within the Nobatron. Therefore, the internal circuitry should not be touched until the input power has been externally disconnected.

Input Fuse: An input fuse is provided on the front panel to protect the Nobatron's circuitry in the event of an internal failure.

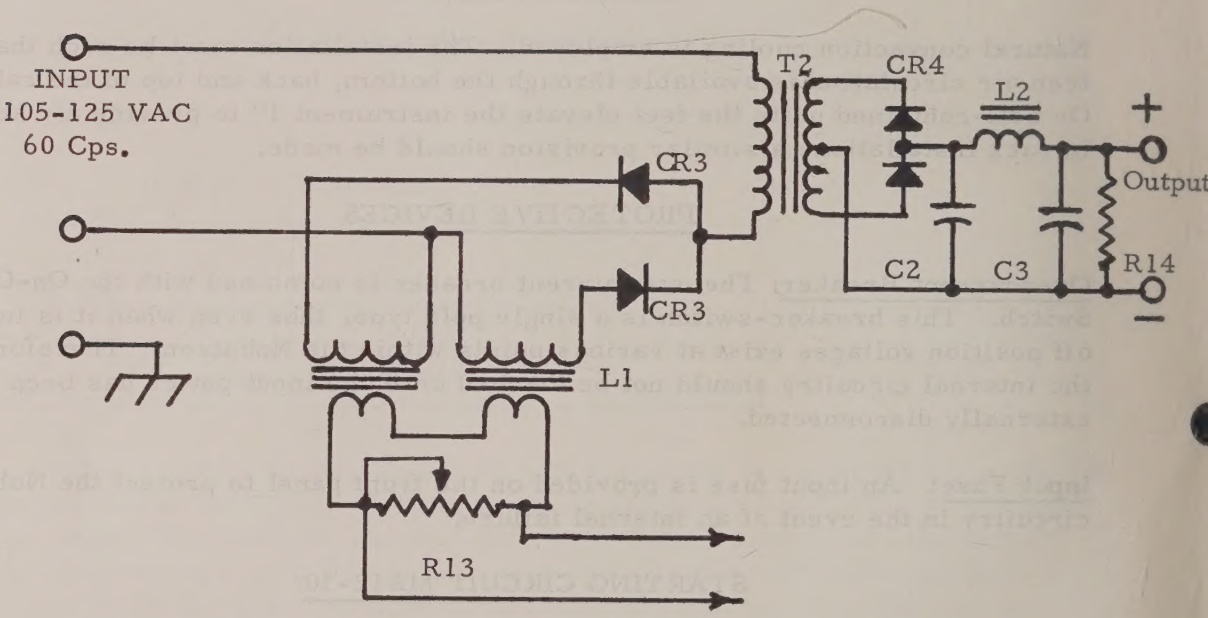
STARTING CIRCUIT MA12-30

In Model MA12-30 a starting circuit (CR5, C7, R15 & K2) is used to protect the Mag Amp Rectifiers from high peak inverse voltages that may occur at turn-on. The contacts of relay K2 are normally closed. This places a short across the Mag Amp circuit immobilizing it until the control circuit reaches operating voltage. After a predetermined time delay, relay K2 operates thus removing the short from the Mag Amp. The Mag Amp will now function in a normal manner.

IV. PRINCIPLE OF OPERATION

Sorensen "MA" Nobatrons employ a power, self-saturating, magnetic amplifier followed by a filter section, together with a transistorized control circuit.

Power Circuit



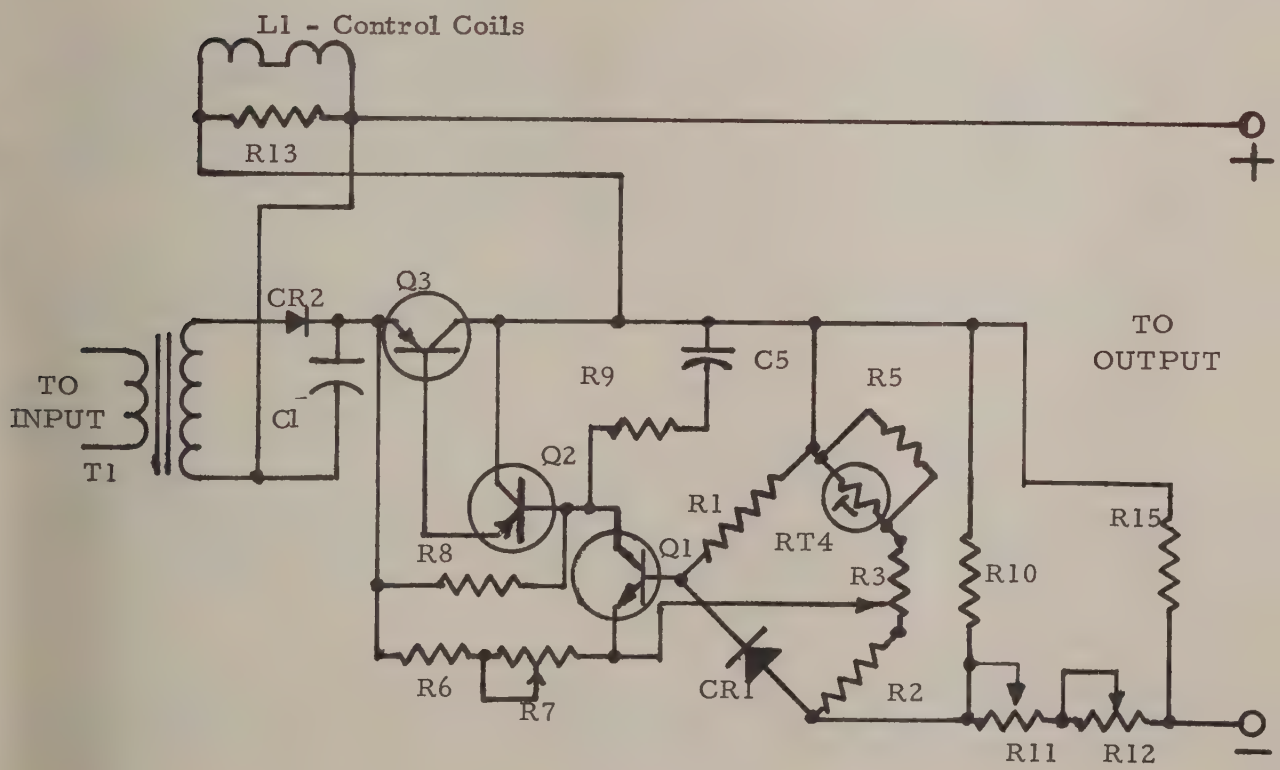
L1 - Self-saturating Magnetic Amplifier
L2 - DC Filter Choke
T2 - Rectifier Input Transformer
CR3 - Rectifier for Magnetic Amplifier
CR4 - Power Rectifiers
C2 - Input Filter
C3 - Output Filter
R13 - Anti-surge Resistance across DC coil of L1
R14 - Bleeder to provide minimum load

Power Circuits (Cont.)

The heart of the power section is a Magnetic Amplifier. For a detailed discussion of Mag Amps, refer to Storm* Magnetic Amplifiers. The AC coils of the Mag Amp act as "gates" which open alternately at some time during the half cycle in which each CR3 conducts. Current flows during the half cycle period that each gate is open. The amount of current depends on the fraction of the half cycle period that the "gate" is open. The fraction of the half cycle period is controlled by the current in the DC windings of the Mag Amp (L1). Since the reactor is of a self-saturating type, a high output is obtained with no current in D. C. winding. Increasing the current in the D. C. winding increases the control ampere turns which will either increase or decrease the output current. The points of operation, which is determined by the output of the unit at the time the change occurs, determines whether the current will increase or decrease with an increase in ampere turns.

The remainder of the power circuit consists of a step-down transformer, a center-tapped full wave rectifier, and a filter section.

CONTROL CIRCUIT



*Storm, H. F., "Magnetic Amplifiers", John Wiley & Sons, Inc., New York, New York, 1955.

T1 - Control Power Transformer
L1 - Magnetic Amplifier
CR1 - Reference Diode
CR2 - Auxiliary Supply Rectifier
C1 - Filter
C5 - Oscillation Suppression
Q1,2- Amplifiers
Q3 - Series Passing Transistor

R2 - Dropping Resistor for CR1
R2,3 - Voltage divider & Potentiometer
RT4&R5 - Temperature Comp.
R6,7 - Line Comp.
R8 - Q1 Load
R9 - Oscillation Suppression
R10 - Bleeder for Reference
R11 - Output Voltage Centering
R12 - Output Voltage Adj. (Front Panel
R13 - Anti-Surge
R15 - Bleeder for Reference

The control circuit in these Nobatrons is a "Power Reference" consisting of a series transistor voltage regulator. The output of the Nobatron is compared directly to the reference through the control winding of the magnetic amplifier, L1. Any change in the output due to line or load change produces an "error" voltage across the control winding. This voltage causes a current flow which changes the firing point of the magnetic amplifier, thus correcting for the change in output. The degree of correction, and hence the regulation accuracy, is determined by the gain of the magnetic amplifier core, the turns and resistance of windings, and the regulation accuracy of the "power reference".

Reference Source: The silicon diode, CR1, is operated in its zener or reverse current region. Under this condition a constant voltage will appear at the terminals of the diode as the current varies within certain limits. CR1 is one arm of a bridge circuit consisting of R1, R2, R3, and RT4 & R5, arranged so that any change in the output voltage will result in a change in the emitter current of Q1. (Please refer to the schematic on the previous page).

Amplifying Transistors: The signal between the base and emitter of the first transistor Q1, is amplified by transistors Q1 and Q2, then applied to the base of the power transistor Q3.

Power Transistor: The power transistor, Q3, regulates the output of the "power reference" by the total voltage drop from the emitter to the collector. In order to reduce the power loss in this transistor, its total voltage supply (which is connected to the emitter) is the sum of the output of the Nobatron and a voltage from the auxiliary power supply. The auxiliary power supply consists of T1, CR2, & C1. This supply is connected to the input power line. (Please refer to the schematic on the previous page).

Temperature Compensation: RT4 is a Negative Temperature Coefficient Resistor which is used to counter balance the positive temperature coefficient of the remainder of the circuit.

Line Compensation: Compensation for input line voltage changes are accomplished in the "Power Reference" by applying voltage from the auxiliary power supply to the emitter of Q1 through resistors R6 & R7.

V. MAINTENANCE AND REPAIR

MAINTENANCE

During normal life these Nobatrons require no maintenance other than the care afforded similar equipment. It is suggested that excessive dust be removed periodically, exercising care to prevent damage by cleaning tools or strong air blasts.

SPARE PARTS

All components used are of a good commercial grade and can be expected to give a reasonably long period of trouble free service. As the age of the Nobatron increases, some components are likely to deteriorate. We suggest that you note those items asterisked on the Parts List, which we recommend be kept on hand.

In the event it is necessary to replace any part, we strongly suggest that the replacement part be of the same value as the original. Substitute parts should not be used unless we assure you that the substitute will not impair the performance of your Nobatron.

REPAIR

CAUTION: DANGEROUS VOLTAGES EXIST IN THESE NOBATRONS. PLEASE OBSERVE APPROPRIATE PRECAUTIONS.

TEST VOLTAGES

Typical circuit voltages are included on the schematic supplied with this manual. All DC voltage measurements should be taken with a 20,000 ohms/volt meter. Readings should be taken at 115VAC input, nominal output voltage, and one-half rated load.

TROUBLE SHOOTING CHART

Symptom	Cause	Procedure for Repair
No Output Voltage	Blown Input Fuse	Replace Fuse
	Breaker SW1 Tripped	Reset Breaker
	Open Power Circuit	Check L1 power windings, T2 voltages, CR3&4, L2 or Ammeter
High Output Voltage	Control Circuit Failure	Check control circuit per schematic for test voltages. Typical causes could be failure of Q1, 2&3, CR2, C1, T2, or L1.

TROUBLE SHOOTING CHART (Contd.)

Symptom	Causes	Procedure for Repair
Low Output Voltage	Control Circuit Failure	Check control circuit per schematic for test voltages. Typical causes could be failure of CR1, or Q1, 2&3 shorted emitter to collector
High Ripple	Filter Circuit Failure	Check L2, C2&3
Poor Regulation	Input out of Specs.	Check Specification in manual for input voltage and frequency
	Failure of CR1	Replace CR1 Zener Diode
	Failure of Line Compensation	Adjust Potentiometer R7, check resistor R6
Periodic Oscillation (hunt)	Excessive High Gain in L1	Adjust Resistor R13 in parallel with L1 DC control winding. Check R6 & 7, C5 & R9
Unable to obtain Full Range of Output Voltage	Load & Range beyond Specifications	Check specifications in manual
	Misalignment of Adjustment	Adjust slider on R11

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